MDE Product Development Team
January FY14 Monthly Report
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(Compiled and edited by S. Benjamin and B. Johnson)

Executive Summary

Task 1: Improve turbulence guidance from NWP forecasts

- RAPv2 has run in NCO parallel cycle at NCEP without crashes since beginning of 2014.
- At RAP status meeting with NCEP Director on 10 Feb, **RAPv2 given final approval for implementation** at **12z Tuesday 25 February 2014.**
- RAP/HRRR presentation at December 2013 annual NCEP Model Production Suite Review, available at **http://ruc.noaa.gov/pdf/NCEP_PSR_2013_RAP_FINAL_v5.pdf**
- Three real-time parallel RAP cycles (with extensive verification of each toward RAP version 3) running on Zeus to evaluate further likely enhancements to RAP data assimilation / model system for spring 2014 code freeze and to be implemented at NCEP in 2015.
- All three parallel RAP cycles on Zeus now running with WRFv3.5.1 and upgraded physics; testing of possible further modifications continues.
- NCEP making continued progress on NAM and NAM-nest
- Testing shows success in optimizing parameter setting for hybrid ensemble data assimilation in RAPv3 for Spring 2014 code freeze
- Testing of using background 2m forecast field for dewpoint/temperature instead of 8m fields showing significant positive impact in RAP data assimilation.

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Good progress on optimizing HRRR run configuration within the EMC environment with 3-hourly real-time test runs ongoing, using MRMS 15-min radar data. Implementation date now set at NCEP as 15 July FY14.
- Development and testing of upgrades to RAP and HRRR for retrospective 2013 warm season evaluation. Code freeze planned for March 2015.
- Hourly and 15-min RTMA surface analyses continues to run in real-time with grids available on ftp for external users

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Latest version of Grell-Freitas cumulus scheme in RAP deemed fit to replace old G3 scheme for RAPv3.
- RAP-dev cycles now all running with likely RAPv3 physics configuration. Testing continues toward reducing or eliminating cold nighttime bias over snow cover and dry daytime dew-point bias in summer. Implementation of this physics configuration expected in RAPv3 (in ESRL in Mar 2014 and at NCEP in winter 2014-15)
- RAPv2 updated physics configuration continues to run in both RAPv2 at GSD and in parallel cycle on WCOSS machine at NCEP [MYNN boundary-layer scheme (Olson version), 9-level PBL, updated Thompson microphysics, others]

Task 4: Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

- Real-time, frozen RAPv2 (matching NCEP RAPv2)/HRRR system continues to run successfully with gridded field dissemination into winter 2013-14 although CoSPA officially shut down on 1 Nov 2013.
- HRRR "failover" capability to use feed from Zeus instead of Jet during Jet downtime continued to work.
- GSD plans for HRRRv2 follows physics changes for RAPv3, and a plan to be implemented on Jet and Zeus by early April 2014 and at NCEP in 2015.

Task 1: Improve turbulence guidance from NWP forecasts

Improving turbulence forecast quality involves efforts to improve initial conditions for the RAP and NAM (and HRRR and NAM Nest models) and to improve the models (WRF-Advanced Research WRF (ARW)-RAP and NOAA Environmental Modeling System (NEMS)- Nonhydrostatic Multi-scale Model – B (NMMB)).
Tasks will include:

- Continuing evaluation of RAPv2 toward early 2014 implementation at NCEP, incorporating changes developed in 2012 and early 2013
- Development of RAPv3 toward 2014 implementation at ESRL and subsequent implementation at NCEP
- Collaborating on developing and testing best approaches for use of hybrid/EnKF/3DVAR data assimilation within common GSI coding structure.

ESRL

Regarding the operational NCEP RAP

The operational RAP (RAPv1) has run without any technical problems, including in the post processing, through the first 6+ weeks of 2014.

Progress toward RAPv2 implementation at NCEP
The NCO RAPv2 parallel cycle has run without crashes since Geoff Manikin at GSD's direction switched back to hypsometric_opt =1 in the WRF name list on 30 December 2013 (see 2014Q1 report for more details on this). Thus, the NCO 30-day reliability test of RAPv2 functionality was passed successfully. At the meeting on Monday 10 February with the NCEP director to review RAPv2 status and results of the field test, the Aviation Weather Center, Storm Prediction Center and Weather Prediction Center, plus the National Weather Service regions including Alaska, all spoke for implementation, all finding that RAPv2 performance is substantially improved over RAPv1. The NCEP director then gave his approval for implementation, scheduled by NCO for 1200 UTC Tuesday 25 February.

The RAP web page **http://rapidrefresh.noaa.gov** was updated with latest information on the planned RAPv2 implementation. A link to the RAPv2 Technical Implementation Notice was added there also. A webpage on RAP output grids from NCEP was updated at **http://ruc.noaa.gov/rr/RAP-NCEP-output-grids.html**.

GSD (Haidao Lin) has carried out a significant study on the impact of radiance bias correction for the Rapid Refresh. When implemented, this change will allow the RAP to use satellite radiances more effectively by removing any expected biases by tracking previous biases on a channel-by-channel basis. This report will be included in the next MDE monthly report.

RAPv3 model testing
This is going well, with use of the 3 development cycles on Zeus plus retrospective testing of candidate changes for improved summer performance. Some highlights follow; all in the context of the WRFv3.5.1 release.

- After considerable further testing and changes by Georg Grell, the Grell-Freitas scheme is now performing well (see Task 3); this latest version will almost certainly be part of the RAPv3 physics suite.
- A modification to snow building that is more restrictive regarding areas where snow is built, but builds more snow cover in these areas, is giving much better results than the earlier RAPv2 version and has been moved into all the RAP-dev cycles at GSD.
- Complementary to this, without artificial augmentation (snow building), snow cover in much of the western US is deficient in RAP, leading to both analysis and forecast errors for temperature. Deficient snow cover is related to poorer radar coverage over the West due to fewer radars, often-severe blockage of the radar beam by terrain, and shallower precipitating clouds in winter, further limiting the ability of radar to see current precipitation. David Dowell looked into this carefully during January and found that the cloud analysis was using a mapping of volumes of air that are not visible to any of the 88D radars, because of either beam blockage by terrain or remoteness of radars, that was not nearly as restrictive as it should have been. As a result, the 0-1h precipitation that serves, as input into the land-surface model has been seriously deficient, and certainly accounts for some of the western CONUS snow-cover issues that have been noted in previous MDE reports. An alternative radar mask was located and tested on a case with considerable precipitation in the Intermountain West, with the result that appreciable volumes that had no echo in the NSSL MRMS radar reflectivity product were in fact subject to terrain blocking. This alternative radar mask will soon be introduced into the RAP-dev runs, with the result that

the hydrometeor analysis will have greater input from the 1-h forecast and less from MRMS. We anticipate this will greatly improve snow cover in the West.

- A modification to the GSI data assimilation for 2m dewpoint and temperature observations using a 2-m forecast background field instead of the previous ~8-m fields is showing very positive impact on further reducing near surface biases for moisture and temperature. This modification has been is in continued testing by Ming Hu and becoming a likely and important component of the RAPv3 change package.
- Joe Olson and Tanya Smirnova continue to investigate possible causes of an appreciable nighttime cold bias over snow cover (see Task 3).
- New precipitation-type verification is being tested with retrospective and real-time RAP and HRRR output. The absence of human observers at many stations is a handicap for verifying "wintery mix" precipitation, since automated detection algorithms have difficulty in distinguishing between precipitation types, particularly when the ice pellet (sleet) type is involved. Because the WRFv3.5 Thompson microphysics produces very little graupel in weak vertical motions typical of forecasts at 13km horizontal grid resolution, the RAP precipitation-type algorithm, which uses the mix of precipitation types predicted by the model to diagnose, has been adjusted to allow for a lower threshold of graupel precipitation rate in order for ice pellets to be identified as a predicted precipitation type (the algorithm allows for the possibility of multiple precipitation types).
- As part of their ongoing monitoring of RAPv2 performance during 2013, the SPC has drawn our attention to a situation that arose during the 17 November 2013 tornado outbreak in the Midwest, in which the 0-h ML (mixed-layer) CAPE at Lincoln IL was too small. We will be looking at this case carefully to determine if a defect in the GSI cloud analysis or some other issue led to this behavior.

Initial RAPv3 testing report is available at
http://ruc.noaa.gov/faa-mde/RAPv3-evaluation-15feb2014.pdf
(Deliverable)

RAP report on satellite assimilation using ensemble/hybrid data assimilation is available at:
http://ruc.noaa.gov/faa-mde/2014_AMS_Lin_EnKF-satellite-assim.pdf

Other activities, some noted more fully under other tasks, also were undertaken:

- Tanya Smirnova has been working with Wei Wang of NCAR on changes to the WRFv3.6 preprocessing system to accommodate new vegetation fields. In this connection, Tanya discussed with Jonathan Case of NASA Huntsville availability of near current greenness fraction fields. Use of these could potentially give a substantial improvement in the calculation of transpiration over the climatological greenness fraction fields now in use for seasons when the spring green-up is substantially earlier or later (e.g., 2013) than usual.
- Retrospective testing for both RAP and HRRR of the impacts of proprietary in situ tower wind data and other special data under funding from the DOE Wind Forecast Improvement Project was concluded and a report is being written for DOE.
- Discussions with EMC continue concerning the best procedure to ensure that proprietary wind tower and nacelle wind measurements are available to the operational RAP and NAM.
- Quasi-biweekly telecons between GSD and the Storm Prediction Center of NCEP continue to be very beneficial. An example is the November 2013 case noted above.
- Several of GSD's RAP/HRRR developers traveled to Atlanta in early February for the Annual Meeting of the American Meteorological Society. These developers at this collection of meetings presented a total of 17 papers and posters pertaining to the RAP and HRRR.
- On 12 February Stan, Steve Weygandt and Curtis Alexander participated in the initial telecons of FAA's Numerical Modeling Strategic Planning Team.

NCEP

As reported in the last report, a bug was found in late December in the NCAR code that recomputed heights on the boundaries. This bug was associated with the log {P} hypsometric option that is being used in version 2, and it likely explains the parallel crashes in November and December. Making major changes to the parallel was deemed undesirable at this time, so it was decided to retain the simple switch back to P version of hypsometric option instituted in late December as well as to retain the earlier changes of modifying the boundary terrain and smoothing the terrain over Greenland. Those terrain changes will likely be removed for Version 3. The parallel RAP has been running stably through the entire month of January and through this date in February. The NCEP Director was briefed on 10 February and

RAPv2 is scheduled for implementation on 25 February. GSD delivered HRRR code to EMC in January, and testing is underway. The initial phase of testing involves making a cycle fit within the one-hour time window, given the allocated resources. IBM is working to help speed up the larger components of the code. (Geoff Manikin)

The GSI analysis is a major component of both RAP and of NAM. A new module, genex_mod.f90, has been created as a straightforward tool to remove the use of full horizontal domain arrays from GSI. To be successful, the tool must be applied systematically throughout the GSI. When this is accomplished, it will allow the GSI to run efficiently on 1000s of processors, which is not currently possible. The genex module allows easy manipulation of rectilinear arrays. With genex, it is very easy to rearrange arrays, processing, and communications so that the subdomains have arbitrary width halos, and can have different widths along each of the 4 sides. It is also easy and efficient to update the halo points. Currently in GSI, the halos are updated only by transforming from subdomains to full horizontal arrays and then back to subdomains again. The first routines to be converted to use genex are psichi2uv_reg and psichi2uvt_reg, which are used in regional models to convert from stream and potential function to u and v. The new routines only need to update halos, using genex, resulting in a much simpler code. One issue is that results with the new code are not bitwise identical to results with the original code because do-loops in the adjoint routine pshchi2uvt_reg needed to be rearranged. Bitwise reproducibility over different numbers of processors must be satisfied by all GSI code. Wan-Shu Wu has tested these new routines on a few 12-hour partial cycles with the NAM NDAS parallel and the differences appear to be reasonable.

Note that there is no significant saving of run time or memory with this change with the current RAP & NAM parent runs. Significant savings are expected with. It is expected that converting to genex will improve the performance of GSI significantly for the higher resolution CONUS NAM nest and with the HRRR and it will now allow GSI to keep pace with future resolution increases. (Dave Parrish)
Comments from the evaluators of NCO's official 30-day RTMA/URMA parallel were addressed. While all the evaluators voted for the package's implementation, it was also made clear that future work should include improving the background for regions of complex terrain. After a successful briefing of the NCEP Director, **the RTMA/URMA package was implemented on January 28, 2014**. A conference call was held with Professor John Horel from the University of Utah and his collaborators to discuss potential observation quality control improvements for the RTMA/URMA. One example is making the rejection limits used by the gross error check to be a function of the local variability in the background. Another conference call was held with NWS Western and Eastern Regions to discuss the next major improvements for the RTMA/URMA. Emphasis was on the need to experiment with a blended HRRR/NAMnest background to address RTMA/URMA's current poor analysis of cold pools over complex terrain. Future versions will add more parameters such as cloud base (ceiling), cloud amount (aka cloud cover), and sea-level pressure. (Manuel Pondeca, Steve Levine, Yuqiu Zhu)

The ceiling code in the NCEP post was tuned and tested to fix unrealistically high cloud ceilings over areas with fresh snow and very low temperatures. A mismatch in microphysics names was also corrected in the NCEP post to stop producing unrealistic visibility from the two SREF NMMB members that use GFS physics. Both fixes have been included in the SREF interim package that is scheduled for implementation in March. (Jun Du)

The NARRE-TL was tested using the parallel RAPv2 to confirm that after RAPv2 becomes operational, the NARRE-TL will automatically access operational RAPv2 files. An experimental web site for NARRE-TL with parallel RAPv2 results was established. The operational NARRE-TL was compared to NARRE-TL using parallel RAPv2 forecasts for a Jan 5 dense fog case in NY and a Jan 15 dense fog case over VA-DC-MD. The results showed the visibility products from both ensembles were similar for these two dense fog cases, but the fog product (distinct from the visibility product) showed large improvement in the new NARRE-TL. A review was completed of the ‘ceiling’ code used exclusively for RAP to produce ‘cloud-base height’ from the unified post processor versus EMC's ceiling code in the unified post processor. (Binbin Zhou)

Development of an hourly updated version of the NAM known as the NAM-Rapid Refresh (NAMRR) was continued on NOAA's R&D machine. The current configuration of NAMRR includes cycling both the full North American continental 12 km parent and the CONUS 3 km nest. Each data assimilation step makes use of a hybrid ensemble-3DVar analysis method through the use of the Global Data Assimilation System’s EnKF members to provide the ensemble contribution to the hybrid background error covariance. The NAMRR also features cloud analysis and diabatic digital filter initialization with radar-derived temperature tendencies. The NAMRR was used to help in the evaluation of a new update to the Ferrier microphysics package, known as Ferrier-Aligo, which is intended to improve the initial representation and characterization of deep convective storms. The NAMRR's use in a collaborative wind energy data denial project known as POWER (Position of Offshore Wind Energy Resources) was completed and results from the project are now being written as part of a report to the Department of Energy. (Jacob Carley)

CAPS

During January 2014, CAPS performed some additional tests with the 40/13 km dual resolution hybrid scheme for the standard 10-day test period, and worked on drafting a manuscript documenting the results. CAPS also hired onto the project, Gang Zhao, a new Ph.D. graduate from OU to replace Yujie Pan, who is leaving in mid-February. Efforts were made to set up the RAP EnKF and hybrid DA systems to run on an NSF supercomputer at the Texas Advanced Computing Center (TACC), which can potentially allow experiments that require more computing resources than available on GSD machines. New scripts had to be written, and good progress has been made. Discussions were made between CAPS and GSD at the AMS Meeting on establishing a newest version of the EnKF and hybrid and test for more recent period.

Additional information on RAP-related tasks

ESRL

GSD continues to make pgrb and bgrb files from the ESRL/GSD RAP-primary (RAPv2) real-time 1-h cycle available from its FTP site for users in NWS and other labs**.**

NCEP

NCEP maintained real-time availability of SAV and AHP guidance to all vendors from the operational hourly RAP on pressure surfaces via the NWS Family of Services (FOS) data feed and via the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (EMC&NCO)

NCEP maintained real-time availability of full resolution gridded data from the operational RAP runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/rap/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.rap_CY.00 through MT.rap_CY.23. This includes hourly BUFR soundings and output grids, which undergo no interpolation. Both sites now contain only grids in GRIB2 format **http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml.** Gridded RAP and NARRE [-TL] fields are available on **NOMADS** for the CONUS domain on 13 km grid #130 and the Alaska domain on 11.25 km grid #242. RAP fields are also available for the larger North American domain on 32 km grid #221. A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov**. Displays of the limited set of fields from the near-real-time pre-implementation parallel runs of RAPv2 have been available for viewing at **http://magpara.ncep.noaa.gov/.** (EMC&NCO)

Verification of RAP

ESRL's verification of the RAP is available from **http://ruc.noaa.gov/stats**. NCEP maintained its capability and provided access to routine verifications of the operational RAP analyses and forecasts. These include grid-to-station verifications versus rawinsonde, surface, aircraft, Profiler, and VAD data computed periodically at NCEP and accessible via NCEP's Mesoscale Modeling Branch website: **http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html** .

Deliverables	**Delivery Schedule**
Task 1 – Improve turbulence guidance from NWP forecasts	
a. Finalize code for RAPv2 for implementation at NCEP (ESRL, NCEP) • Vigorous effort leading complete package with extensive improvements, summary at: **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2013.pdf**	Mar 2013 **COMPLETE**
b. Complete the testing of the 40/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data (GSD, CAPS) • Initial work completed by CAPS, testing of further enhancements to system. GSD testing and inclusion in RAPv2 of hybrid system with full observational data, using GFS ensemble data. Milestones exceed.	Mar 2013 **COMPLETE**
d. Report on early version of RAPv3 primary cycle at GSD with physics enhancements for initialization of the HRRR. (ESRL) Good progress with revised assimilation and WRFv3.5.1 as reported under Task 1. For more completeness, we request a delay to make this report by 30 January 2014. Complete - **http://ruc.noaa.gov/faa-mde/RAPv3-evaluation-**	**Delay to Jan 2014** **COMPLETE**

Deliverables	Delivery Schedule
15feb2014.pdf	
e. Report on options for including satellite data in the RAP ensemble hybrid data assimilation to ensure overall positive impacts of the data (NCEP, ESRL) Complete - **http://ruc.noaa.gov/faa-mde/2014_AMS_Lin_EnKF-satellite-assim.pdf**	**Delay to Jan 2014 COMPLETE**
f. Finalize RAP version to initialize experimental HRRR for 2014 real-time use toward operational HRRR (ESRL)	Mar 2014
g. Deliver progress report on development of NARRE (NCEP, ESRL)	Mar 2014
h. Deliver progress report on ensemble/hybrid data assimilation for use in NARRE (ESRL, NCEP)	Mar 2014
i. Subject to NCEP Directors' approval, upgrades to observation processing and/or quality control and/or GSI and/or NMMB systems become Operational at NCEP. (NCEP)	Mar 2014
j. Incorporate physics and dynamics improvements from the user community, GSD, and NCEP into WRF for use in the Rapid Refresh system. (NCAR-MMM)	Mar 2014

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE
GSD

In January, work continued toward the NCEP operational implementation of the HRRR (scheduled for late Q3 FY14). Curtis Alexander and Geoff Manikin have been working together on this task and continue to make good progress. Previously, Curtis had built an instance of the HRRR run environment on NCEP WCOSS computer and ran the system end-to-end and transferred this package to Geoff. Another very key component that has been put in place is the feed of 15-min radar data from the MRMS system, with work also progressing toward delivery of 15-min radar data from the NCEP internal feed. Geoff now has a quasi-real-time test version of HRRR running every third hour and he and Curtis are making adjustments to the system to further optimize the run-time of the system and update it for transfer to NCO.

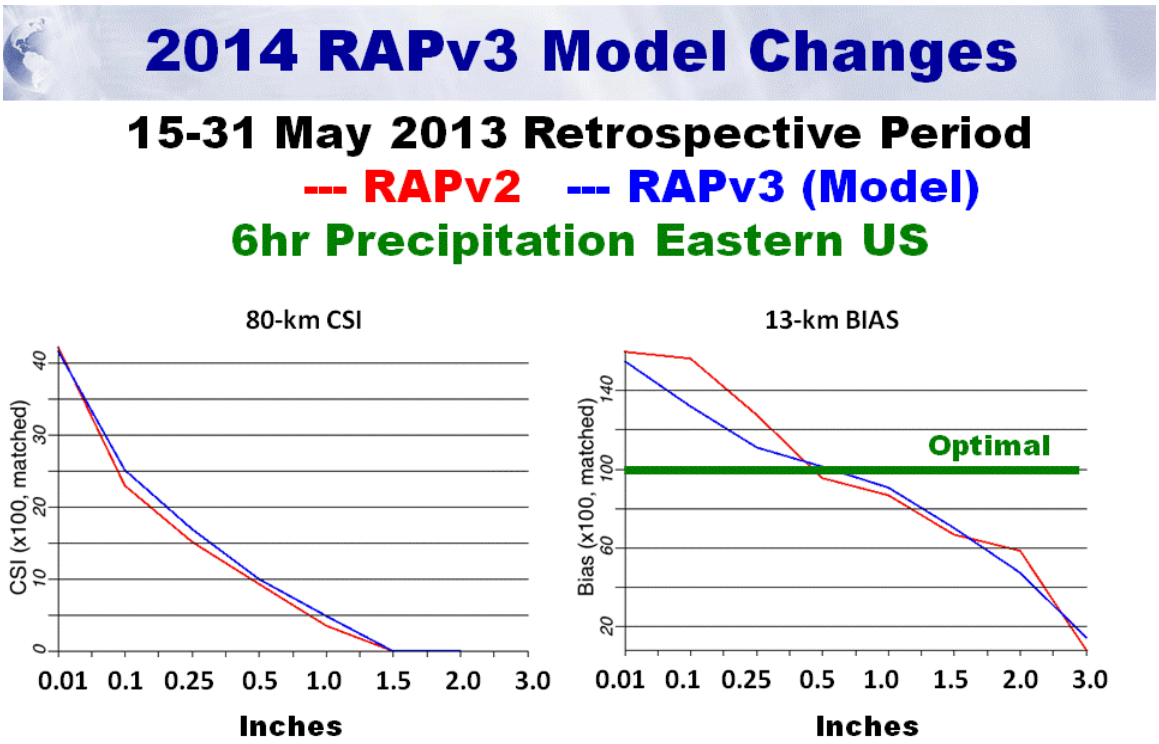
Work has also proceeded to finalize the upgrade package to the GSD RAP and the HRRR for the 2013 warm season evaluation, with a GSD code freeze scheduled for March. Much testing and evaluation has been completed, leading to upgrades to the RAP and HRRR. A partial list of enhancements includes:

RAP AND HRRR MODEL -- upgrade to the WRF version 3.5.1, change to Grell-Freitas cumulus parameterization (RAP only), updates to MYNN PBL scheme and RUC LSM scheme, addition of shallow cumulus scheme (HRRR only).

RAP AND HRRR DATA ASSIMILATION -- upgrade to recent GSI trunk version, improvements to hybrid ensemble configuration (RAP only), improvements to surface observation assimilation, use of mesonet observations and radial velocity (likely), improvements to 3-km latent heating specification (HRRR only, likely).

Additional details on many of these changes are given under task 1.

Preliminary warm season retrospective testing of a partial bundle of these changes completed in January 2014 has shown improvement in upper-level verification (winds, temperature, ands relative humidity) at nearly all levels (not shown) and in precipitation (Fig. 1). The precipitation improvement is significant, as accurate precipitation forecasting requires actually replicating in the model a host of physical processes. Systematic HRRR testing will follow these RAP tests.



As noted under task 1, several of GSD's RAP/HRRR developers traveled to Atlanta in early February for the Annual Meeting of the American Meteorological Society. These developers at this collection of meetings presented a total of 17 papers and posters pertaining to the RAP and HRRR. On 12 February, Stan Benjamin, Steve Weygandt, and Curtis Alexander participated in the initial telecons of FAA's Numerical Modeling Strategic Planning Team.

Patrick Hofmann has continued work on an AMB version of the Real-Time Mesoscale Analysis (RTMA) using the HRRR as a background. He now has hourly and 15-min versions of this running in real-time on Jet and grids from these analyses are being made available to outside users via the GSD ftp server. While at EMC for the NCEP Production Suite Review in early Dec., we held discussion Manual Pondeca and Steve Levine on optimizing parameter setting for the RTMA anisotropic analysis option within GSI.

NCEP

NCEP EMC and NCO conducted a planning exercise of what the modeling suite might look like on the Weather and Climate Operational Supercomputing System (WCOSS) Phase 1 (2013-2015) and Phase 2 (2015-2018). The size of the latter would be enhanced by the Sandy Supplemental funds. This plan incorporated ESRL/GSD along with all other contributors to the NCEP Production suite. NWS Director Louis Uccellini was briefed 28 March 2013. While tentative, these plans called for an initial HRRR implementation on 65 nodes on Phase 1, and a HRRR Ensemble (HRRRE), combining multiple runs with configurations of both WRF-ARW and NMMB, on Phase 2. A sizable bank of computing was dedicated on Phase 2 to advanced data assimilation for the convective allowing scales of the HRRRE, likely involving a 4-dimensional version of the current GSI-hybrid-EnKF.

Deliverables	Delivery Schedule
Task 2 – Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	
a. Report on initial tests of 3-km 15-min RTMA cloud / surface analysis for use in frontal diagnostics, CI assessment and other near-surface assessments (ESRL, NCEP) • *Good progress toward 3km RTMA and RUA surface and cloud analyses* • *Successful initial tests summarized in report:*	Feb 2013 **COMPLETE**

Deliverables	Delivery Schedule
http://ruc.noaa.gov/pdf/GSD_RTMA_report.pdf	
b. Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for 2013 real-time use (ESRL) • *Extensive set of enhancements in place and running in real-time experimental GSD RAPv2 / HRRR system*	Mar 2013 **COMPLETE**
c. Provide preliminary 15-min RTMA surface analyses as experimental improved basis for frontal diagnostics and other diagnostics from surface analyses (ESRL, NCEP) **Prototype HRRR-based 15-min RTMA analysis completed with sample grids and graphics.**	Aug 2013 **COMPLETE**
d. Report on computing resource status on NCEP Central Computing System, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR (NCEP, ESRL) See above discussion concerning ~2014 implementation and Task 4	**June 2013** **COMPLETE**
e. Complete FY13 internal assessment with revised 3-km HRRR running every hour (ESRL) **Assessment complete with very good results seen for 2013 HRRR in objective and subjective verification and high run reliability**	Sept 2013 **COMPLETE**
f. Provide revised 15-min RTMA surface analyses as primary basis for frontal diagnostics and other diagnostics from surface analyses for real-time use in 2014 (ESRL, NCEP). **Real-time 15-min RTMA running with grids available on ftp**	Feb 2014
g. Finalize all changes to the HRRR for real-time use in 2014 (ESRL)	Mar 2014

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE
GSD

The RAPv2 physical parameterization configuration resulting from test and evaluation of physics options during the late 2012 – early 2013 period and described in previous reports will be part of the RAPv2 implementation currently scheduled for 25 February 2014:

- New 9-level configuration of the RUC land-surface model (RUC LSM) with fix to canopy evaporation when the MYNN surface layer is used.
- Mellor-Yamada-Nakanishi-Niino (MYNN) planetary-boundary- and surface-layer scheme (modified considerably by Joe Olson) in place of the Mellor-Yamada-Janjic (MYJ) scheme used in RAPv1.
- Continue use of the Grell G3 scheme from WRFv3.2.1.
- Continue use of the Goddard short wave and RRTM long-wave radiation schemes.
- Use WRFv3.4.1 version of the Thompson microphysics.

Looking toward a mid-late March code freeze for the RAPv3 and HRRRv2 for summer 2014, January saw intensive effort toward arriving at the RAPv3 physics configuration. After successful testing in January, including several runs using the August 2012 and May 2013 retrospective periods, we think we now have the physics suite for the March code freeze essentially set. Below are listed the main features of this suite and significant changes from RAPv2.

- Long and short wave versions of RRTMG. In addition to provision for attenuation of solar radiation by aerosol, RRTMG has a more rigorous accounting for the attenuation of solar radiation by ice and snow recently developed by Greg Thompson. Although RRTMG has available a semi-empirical diagnostic cloud fraction calculation, an alternative, being examined by Joe Olson, is direct coupling with the shallow convection component of the Grell-Freitas convection (see below). Because the RRTMG is more expensive, it will be called every 20min instead of every 10.
- RUC LSM (9-level version) changes. These include 1) treatment of albedo in situations of partial snow cover, which itself must be parameterized, 2) reduction of surface roughness in areas of snow cover over tundra, scrubland and cropland (earlier testing on this was mostly done with the MYJ PBL and surface layers (see further discussion

below), 3) further consideration of the representation of snow melt in low-level warm-advection conditions typical of spring. A combination of retrospective experimentation and real-time evaluation continues toward reduction or elimination of the cold bias over snow.

- Further upgrades to the MYNN surface and boundary layer schemes. See further discussion below on this. These are intended to address two systematic biases that were not completely eliminated in RAPv2: the nighttime cold bias over snow cover noted above in conjunction with the RUC LSM, and the daytime warm and dry bias we see with the RAPv2 under clear skies, particularly during the warm season.
- Replacement of the G3 convection scheme used in RAPv1 and RAPv2 by the Grell-Freitas deep and shallow scheme. Georg Grell has continued to improve the G-F deep convection scheme, and testing on warm-season retrospective periods indicate that it is now no longer degrading precipitation and upper wind forecasts as compared with the old WRFv3.2.1 G3 scheme that was used in RAPv1 and slated for continued use in RAPv2. Use of only the shallow portion of G-F will be considered for HRRR application, pending successful testing over the next several weeks.
- Continued use of the NCAR Thompson microphysics. This continues to work well in the context of other changes for RAPv3.

Ongoing physics-related efforts to further improve the current RAPv3 model performance center on 2-m temperature forecast biases that involve the interplay between the RUC LSM, the MYNN surface and boundary-layer scheme and, in the case of the warm bias, the parameterized convection.

- To overcome a stubborn nighttime cold bias in 2-m temperature over snow cover we are experimenting with decreasing surface roughness over snow cover to decrease coupling of the atmosphere close to the ground with the ground itself, and under very stable conditions increasing the mixing within the atmosphere itself.

- To reduce the surface warm and dry bias over land under clear skies in daytime, most evident in the warm season and discussed in previous MDE reports, we have switched to the RRTMG scheme with its improved accounting for attenuation of solar radiation by (climatological) aerosol and parameterized moist convection through an empirical relative-humidity / fractional-cloud relationship. Direct coupling using estimated fractional coverage by convective cloud from the GF shallow cumulus scheme will be tried in the near future.

Further activities:

- Testing of changes to the Thompson microphysics for WRFv3.5.1. We anticipate these will mainly impact higher rainfall rates and therefore may be of importance for the HRRR configuration in 2014. Evaluation in HRRR has not yet begun, but is expected to be straightforward.
- Tanya Smirnova has been working with Wei Wang of NCAR on changes to the WRFv3.6 preprocessing system to accommodate new vegetation fields to be available for use by WRF Land-Surface Models. In this connection, Tanya discussed with Jonathan Case of NASA Huntsville availability of near current greenness fraction fields. Use of these could potentially give a substantial improvement in the calculation of transpiration over the climatological greenness fraction fields now in use for seasons when the spring green-up is substantially earlier or later (e.g., 2013) than usual.
- New aerosol-aware microphysics from NCAR. On 15 Feb, Greg Thompson sent an email to make available to GSD the aerosol-aware microphysics within WRFv3.6-pre-release. Pending NCAR's preparing the code for transfer to GSD (see item a. under table of Task 3 deliverables below), test and evaluation will begin by GSD. This is a potential major change and will require careful evaluation. In preparation for this, GSD met with Greg Thompson of NCAR on 15 Nov 2013 to plan some details on this transfer. We anticipate significant testing of the aerosol-aware microphysics in 2014 in a parallel development version of RAP toward implementation in the March 2015 ESRL versions of the RAP and HRRR.

NCEP

With the HRRR prediction model running fairly efficiently, NCEP is awaiting the remainder of the HRRR system containing initialization, post-processing and product generation components which must all fit into the allocated space and complete each run within an hour.

NCAR/RAL

CURRENT EFFORTS: In the month of January, G. Thompson made final revisions to the J. Atmos. Sci manuscript and re-submitted it to AMS. The paper is now fully accepted and a copy will be provided to FAA-AWRP once AMS packages

the final text for Early Online release. T. Eidhammer performed some ice initiation sensitivity studies with the new aerosol code and D. Gill made final preparations for including the code in WRF code repository for release in v3.6 (Apr 2014 release date expected).

FUTURE EFFORTS: NCAR-RAL will assist NOAA-GSD to adopt/utilize the new scheme. NCAR-RAL and NOAA-GSD still need to plan and carry out a method to link aerosols/species found in WRF-RAP-Chem to simplify into those variables used by the new microphysics scheme; or, alternatively, use with built-in climatological aerosols.

PROBLEMS/ISSUES ENCOUNTERED: The integration of the aerosol-aware microphysics scheme depends on availability of NOAA-GSD and NCAR-MMM personnel and a timeline of activities has not yet been decided.

INTERFACE WITH OTHER ORGANIZATIONS: None.

NCAR/MMM

Deliver a WRF Users' Workshop and WRF Tutorial for the User Community

NCAR gave a WRF tutorial in Boulder on January 27–31. This covered the basic WRF system, and approximately 60 people attended.

PLANNED EFFORTS: Tutorial scheduled for February 2014 at the University of New South Wales in Australia. NCAR will begin the planning of the 2014 WRF Users' Workshop in this quarter.

UPDATES TO SCHEDULE: NONE

Incorporate Physics and Dynamics Improvements into WRF

NCAR led the oversight of preparations of the next major release, WRF V3.6. NCAR held regular meetings of the Release Committee. The first friendly user release, prior to V3.6, was made this month, which provided the first code for testing and feedback. NCAR will issue a second friendly user release in late February. The V3.6 release will be in Spring 2014, and details on it may be found at: **http://wrf-model.org/users/release.php.**

Jimy Dudhia (NCAR/MMM) worked with A.-J. Deng and Dave Stauffer (Penn State Univ.) on their implementation of PSU shallow convection scheme. This will likely be in WRF, but after V3.6.
Dudhia is also collaborating with visitor Roman Pilon (Univ. of Miami) to evaluate MJO behavior with the 'modified' Tiedtke cumulus scheme.

Dudhia and Ming Chen (NCAR/MMM) prepared various codes for the V3.6 release with Ming Chen. This included resolving a parallelization problem in the new SBM microphysics scheme and working on sea ice with both the new lake model for 3.6 and the new surface layer scheme, sfclayrev. They also obtained updated code from UCLA for the SSiB LSM related to producing 10-m winds.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP and HRRR will continue through this quarter.

UPDATES TO SCHEDULE: NONE

Deliverables	**Delivery Schedule**
Task 3 – Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	**Delivery Schedule**
a. Conduct initial single test of aerosol-aware microphysics in ARW in a RAP configuration as start of a 2014 evaluation for its suitability as part of the RAPv3 prototype for 2015 NCEP implementation (NCAR-RAL, ESRL) • This task name has been changed to accurately reflect the long-term evaluation needed for this complicated change over much of 2014.	Feb 2014. Task name changed.

b. Final model physics code transfer complete to EMC for Rapid Refresh 2 upgrade change package to be implemented at NCEP by spring 2014 (ESRL, NCEP) • Freeze of model physics code for March 2013 version of RAP at ESRL allows this milestone to be met.	Mar 2013 **COMPLETE**
c. Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v2 software to NCO (NCEP, ESRL)	**Sept 2013** **COMPLETE**
d. Transfer upgraded coupled aerosol-microphysics scheme into a test version of HRRR (NCAR-MMM, ESRL) COMPLETE – 15 Feb 2014 – see report above - RAL has made available aerosol-aware microphysics to GSD.	Dec 2013 COMPLETE
f. Finalize microphysics changes and other physics changes to improve icing forecasts for ESRL version of RAP and HRRR for 2014 real-time use (ESRL)	Mar 2014
g. Report summary of icing probability skill measures by quarter for the year. (NCEP)	Mar 2014

Task 4: Develop convection-ATM-specific improvements for guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

Task 4 – Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL)

Current:

A new retrospective period from 15-31 May 2013 has been established to begin evaluation of model and data assimilation changes for the 2014 version of the ESRL RAP and HRRR. A control run for the retrospective period has been completed using the 2013 ESRL RAP and HRRR versions but also include an adjustment in soil temperature and moisture and a correction in the RUC land surface model to remove unrealistic surface evaporation flux in areas of precipitation that were not available during the real-time runs in early May 2013. The code for the WRF-ARW version 3.5.1 update including changes to the Thompson microphysics scheme and associated reflectivity, VIL and echo top diagnostics has been merged with the ESRL RAP and HRRR WRF-ARW code base. RAP retrospective runs with WRF-ARW version 3.5.1 and data assimilation changes have been completed for the May 2013 period along with an upper-level and surface forecast verification comparison to the control run. The experiments include new convective parameterization and radiation schemes and updates to the boundary layer and land-surface schemes with forecast improvements noted in the results when compared to the control run.

Planned:

Evaluation of additional ESRL RAP and HRRR model and data assimilation changes will be conduced using the 15-31 May 2013 retrospective period. Once the RAP changes are ~~determined~~ finalized, HRRR retrospective runs will be executed including an evaluation of the latest Thompson microphysics scheme in WRF-ARW version 3.5.1 along with testing and calibration of the associated reflectivity, VIL and echo top diagnostics for 2014 configurations of the ESRL RAP and HRRR.

Task 4 – Assess HRRR reliability and provide monthly reporting (ESRL)

HRRR Reliability for 0-8 Hour VIL/Echo Tops for January 2014

Jet
All runs: 80.2%
3 or more consecutive missed runs: 94.2% (most meaningful for CoSPA)
6 or more consecutive missed runs: 95.8%
6 outages of at least 3 hrs. or longer
3 outages of at least 6 hrs. or longer

Zeus
All runs: 40.5%
3 or more consecutive missed runs: 47.0% (most meaningful for CoSPA)
6 or more consecutive missed runs: 51.1%
15 outages of at least 3 hrs. or longer
7 outages of at least 6 hrs. or longer

Combined (Jet or Zeus)
All runs: 87.1%
3 or more consecutive missed runs: 94.6% (most meaningful for CoSPA)
6 or more consecutive missed runs: 96.2%
5 outages of at least 3 hrs. or longer
3 outages of at least 6 hrs. or longer

*** NOTE: During January Zeus was used extensively for HRRR development testing and not as a backup capacity with the exception of one day during scheduled maintenance on Jet ***

Under Task 4 – Complete implementation of refined cloud-top cooling (SatCast) assimilation for HRRR for real-time use in 2014

Tracy Smith continued her work with the assimilation of GOES-CI cloud-top cooling radar data within the RAP. Following her initial experiments she has completed an additional retrospective experiment using a higher cooling rate threshold and successfully removed some of the false alarms (see Fig. 1 below), resulting in slight higher skill scores. Additional experiments are ongoing.

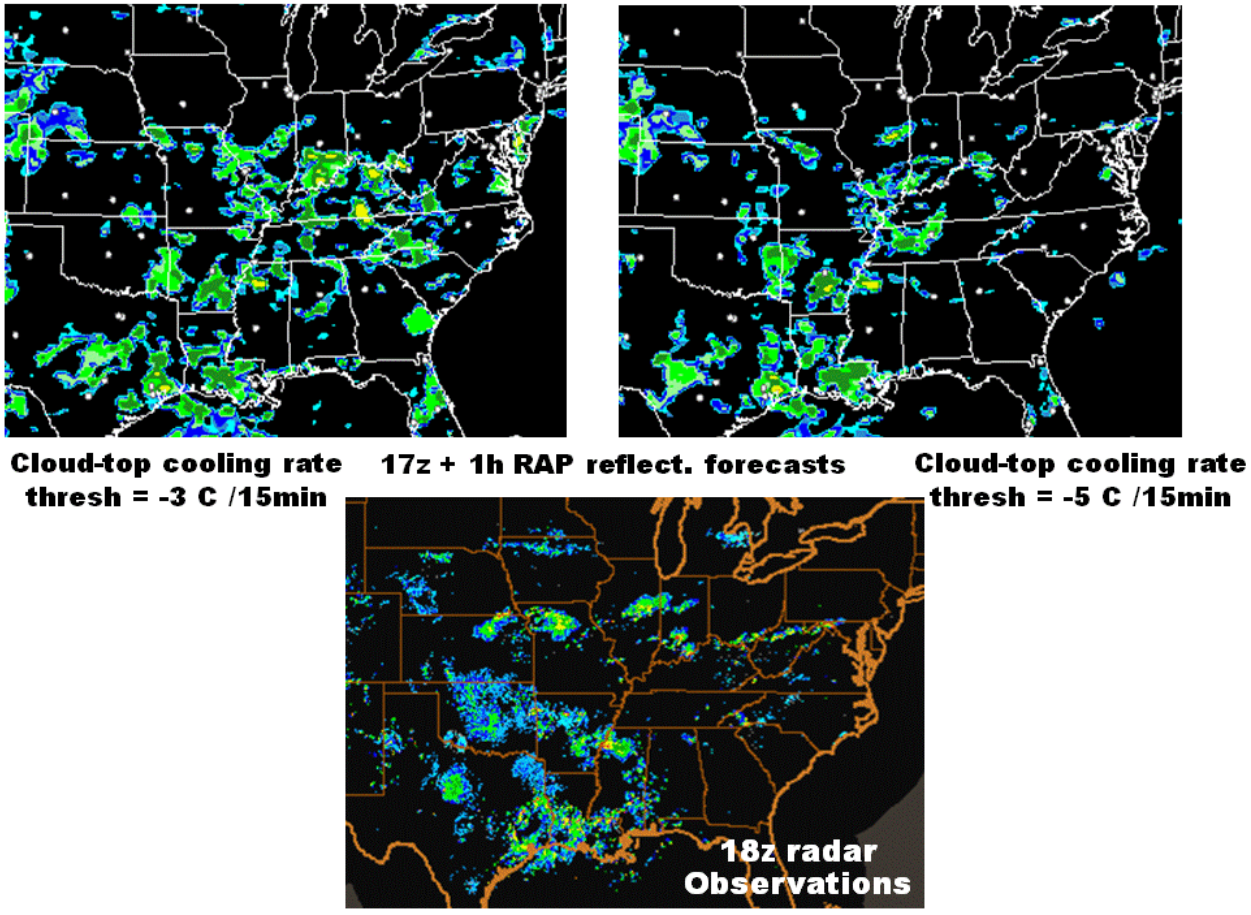


Fig. 1, Comparison of RAP 1-h forecasts valid 18z 8 July 2012 with assimilation of satellite-based cloud-top cooling rate data using a minimum threshold a -3 deg. C per 15 min. (left) and -5 deg. C per 15 min (right).

Comparison with the radar observations (bottom) illustrates the reduction in spurious convection associated with the more restrictive -5 deg. threshold (right).

Also Under Task 4 – Interact with CoSPA (or other) program partner labs and the FAA

Team (ESRL/GSD, NCAR/RAL, and MIT/LL) telecons and e-mail correspondence will continue to occur during the CoSPA offseason regarding upcoming HRRR changes. A planning telecons is scheduled for both February and March 2014 to discuss the CoSPA 2014 demonstration including HRRR model changes for 2014 and progress towards distribution of the HRRR from the upcoming operational implementation at NCEP. Discussion with MIT/LL continues regarding possible collaboration on convective weather avoidance polygons including the potential for feedback on the evolution of the size distribution of forecasted convective structures in the HRRR.

Deliverables	**Delivery Schedule**
Task 4 – Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA	
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL) • Code for revised echo-top / reflectivity diagnostics with revised microphysics implemented in GSD real-time HRRR.	Mar 2013 **COMPLETE**
Conduct baseline testing of the early 2013 HRRR version (ESRL) • Baseline testing of 2013 HRRR version completed as part of code preparation for freeze. Summary of skill score improvements being prepared.	Mar 2013 **COMPLETE**
Report on evaluation of new microphysics scheme and associated echo-top and reflectivity diagnostics in ESRL/GSD RAP and HRRR (ESRL) • *Preliminary evaluation completed and summarized in report:* **http://ruc.noaa.gov/pdf/GSD_reflectivity_report.pdf**	Mar 2013 **COMPLETE**
Assess HRRR reliability and provide monthly reporting (ESRL) Reliability statistics are being reported each month	*Apr 2013* **COMPLETE** *(ongoing)*
Report on evaluation of revised WRFv3.4 microphysics for RAP/HRRR for its effects on echo-top and reflectivity in ESRL RAP/HRRR (ESRL)	Mar 2014
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2014 real-time use of HRRR (ESRL)	Mar 2014
Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014 (ESRL) **Evaluation of preliminary results**	Mar 2014 **Good progress**
Report on 2014 baseline testing of the HRRR (ESRL)	Mar 2014